8.2

APPENDIX B

TECHNICAL PROCEDURES (TP)

TP-1.1-2	TECHNICAL PROCEDURE FOR LEVELING SURVEYS
TP-1.2-5	TECHNICAL PROCEDURE FOR DRILLING AND SAMPLING OF SOILS
TP-1.2-6	TECHNICAL PROCEDURE FOR FIELD IDENTIFICATION OF SOIL SAMPLES
TP-1.2-12	TECHNICAL PROCEDURE FOR MONITOR WELL DRILLING AND INSTALLATION
TP-1.2-14	TECHNICAL PROCEDURE FOR COLLECTION OF GROUNDWATER SAMPLES
TP-1.2-15	TECHNICAL PROCEDURE FOR COLLECTING WATER QUALITY SAMPLES FROM PRIVATE WELLS
TP-1.4-2	TECHNICAL PROCEDURE FOR DETERMINATION OF IN-PLACE DENSITY OF SOILS
TP-1.4-6	TECHNICAL PROCEDURE FOR WATER LEVEL MEASUREMENT
TP-1.4-11	TECHNICAL PROCEDURE FOR SINGLE BOREHOLE DRAWDOWN AND RECOVERY PUMP TEST
TP-2.2-1	TECHNICAL PROCEDURE FOR DETECTING THE PRESENCE OF VOLATILE ORGANICS IN SOIL SAMPLES
TP-2.2-2	TECHNICAL PROCEDURE FOR CONDUCTING NATURAL GAMMA, NEUTRON AND GAMMA-GAMMA BOREHOLE GEOPHYSICAL SURVEYS
TP-2.2-3	TECHNICAL PROCEDURES FOR DETECTING THE PRESENCE OF VOLATILE ORGANICS IN WATER SAMPLES

APPENDIX B
(continued)

TP-3.1-1	TECHNICAL PROCEDURE FOR DETERMINATION OF THE MOISTURE CONTENT OF SOILS
TP-3.1-5	TECHNICAL PROCEDURE FOR THE LABORATORY CLASSIFICATION AND DESCRIPTION OF SOILS
TP-3.1-12	TECHNICAL PROCEDURE FOR DETERMINATION OF PERMEABILITY OF SOIL SAMPLES

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NO. OF COPIES	DOCUMENT AND REVISION
1	TP-1.4-6 Revision 1
1	~~TP-1.1-2 Revision 2~~ TA 8/27/85
1	TP-1.2-5 Revision 2
1	TP-1.2-6 Revision 4
1	TP-1.2-12 Revision 1
1	TP-1.2-14 Revision 1
1	TP-1.2-15 Revision 0
1	TP-1.4-2 Revision 1
1	TP-2.2-3 Revision 0
1	TP-1.4-11 Revision 0
1	TP-2.2-1 Revision 0

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CONTROLLED DOCUMENT RECORD OF RECEIPT

1	TP-2.2-2 Revision 0
1	TP-3.1-5 Revision 2
(	TP-3.1-1 Revision 1
\	TP-3.1-12 Revision 1

Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

TITLE	EFFECTIVE DATE	REV. LEVEL
TP-1.4-6 TECHNICAL PROCEDURE FOR WATER LEVEL MEASUREMENT		
PREPARED BY Douglas J. Howell Feb 11, 1985 — APPROVED [signature] 2-11-85 — APPROVED [signature] Feb 11/85		1
CONTROLLED DOCUMENT		

Revision Level	Page No.	Section No.	Revision Made TP-1.4-6
1	Page 2	Sect. 7.1	Added "... or measuring tape with a wetting surface."
		Sect. 7.5	Added.
		Sect. 8.2	Added last sentence.
		Sect. 8.3	Added last sentence.
		Sect. 8.4	Revised.
		Sect. 8.5	Added.

1.0 PURPOSE

This technical procedure is to be used to establish a uniform procedure for measuring water levels in drill holes and piezometers.

2.0 APPLICABILITY

This technical procedure is applicable to all persons or parties engaged in measuring water levels.

3.0 DEFINITIONS

Electric Water Level Sounder (EWS). An instrument for measuring water levels in boreholes. An EWS is essentially an open circuit involving an ammeter and battery mounted on a reel on which insultated two-wire electric cord (calibrated by length) is wound. The circuit is closed when the exposed ends of the two wires are immersed in water. Amperage is registered on a meter on the reel.

4.0 REFERENCES

Cooley, R.L., et al, 1972, Hydrologic Engineering Methods for Water Resources Development, Vol. 10-Principles of Groundwater Hydrology, Section 6.01, U.S. Army Corps of Engineers (HEC-IHD-1000).

5.0 DISCUSSION

None.

6.0 RESPONSIBILITY

6.1 Each Field Engineer measuring water levels shall be responsible for proceeding with the measurement in complance with this technical procedure.

6.2 Task Leader shall be responsible for:

- o Direct supervision of personnel taking the measurements
- o Assurance that equipment and material are available to permit accomplishment of the task.

7.0 EQUIPMENT AND MATERIALS

7.1 Electric water-level sounder or measuring tape with a wetting surface.

7.2 Folding rule.

7.3 Field notebook and writing implements.

7.4 Data on well identification numbers and locations.

7.5 Spare battery for electric water-level meter.

8.0 PROCEDURE

8.1 Record well identification number.

8.2 Clean all downhole instruments and equipment between wells.

8.3 Measure and record distance from ground level to top of casing or standpipe. Measure the vertical distance from the top of casing or standpipe to the point of the elevation survey (usually are the same).

8.4 Turn on EWS, check battery, lower wire into borehole or standpipe and stop at depth where amperage indicates a completed circuit. Record length of wire below casing collar or top of standpipe to the nearest 0.05 foot. The markings on the wire line need to be independently checked with a measuring tape for accuracy, both above ground and down-hole.

8.5 If a measuring tape is used, lower the tape (with a weight attached) into the borehole. The tape must be lowered a sufficient length to be submerged within the well water and have it's wettable surface corresponding to the surface of the well water. The total length of the tape within the well (from the top of casing or standpipe) and the length of the wetted surface to the submerged end of the tape shall be recorded.

8.6 Repeat above procedure on one of the wells each day to be measured for precision.

8.7 Record date and time.

Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

TITLE TP-1.2-5 TECHNICAL PROCEDURE FOR DRILLING AND SAMPLING OF SOILS	EFFECTIVE DATE	REV. LEVEL
PREPARED BY Douglas J. Morell Feb. 11, 1985 APPROVED 2.11.85 APPROVED Feb 11/85		2
CONTROLLED DOCUMENT		

Revision Level	Page No.	Section No.	Revision Made TP-1.2-5
2	Page 1	Sect. 1.0	Changed "foundation investigations" to "geotechnical".
	Page 2	Sect. 3.8	Added.
		Sect. 6.4	Added "/Hydrogeologist".
	Page 5	Sect. 8.2.1	Revised first sentence.
			Revised line 9 "as deep as possible or to..." to "a maximum depth of usually 100 ft."
			Added last sentence about casing.
		Sect. 8.2.5	Revised "split tube sampling" to "soil" sampling.
	Page 6	Sect. 8.2.6	Added.
		Sect. 8.3.1	Deleted reference to Ringold Formation and blows required to drive sampler.
	Page 9	Sect. 8.7	Added.
		Sect. 8.8.1	Changed "Field Manager" to "Field Engineer or Geologist".
	Page 10	Sect. 9.0	Deleted.

1.0 PURPOSE

This technical procedure is to be used to establish uniform and consistent drilling and sampling procedures of soils for geotechnical investigations. 2

2.0 APPLICABILITY

This technical procedure is applicable to all persons or parties engaged in the subsurface soils investigations.

3.0 DEFINITIONS

3.1 Subsurface Investigation. Investigation accomplished by penetrating and sampling the in situ soils to provide samples for identification, classification, and testing purposes.

3.2 Drilling Procedures. Those methods, techniques, and equipment best suited to advance the hole for the purpose of sampling the in situ materials.

3.3 Sampling Procedures. Those methods, techniques, and equipment best suited to provide optimum recovery of the in situ materials together with their relative consistencies.

3.4 Split-Tube Sample. Disturbed soil sample obtained by driving a split-tube sampler into the soil.

3.5 Pitcher Sample. Undisturbed soil sample obtained by utilizing a pitcher sampler. The samples are recovered in thin-walled metal tubes, 3-feet long and having an inside diameter of 3 inches.

3.6 Push Tube Sample. Undisturbed soil sample obtained by pushing a thin-walled metal tube into the soil by utilizing the hydraulic system of the drill rig. Samples are recovered in thin-walled metal tubes having an inside diameter of 3 inches.

3.7 In Situ Soil. The in place soils that are tested/sampled in their natural position.

3.8 Drive-Tube Sampler. A 3- to 4-inch diameter, 3- to 4-foot long heavy walled metal tube that can be driven into soils and retain the sample while removing the sampler from the borehole. 2

4.0 REFERENCE

4.1 ASTM Standards, 1980. Standard Method for Penetration-Test and Slit-Barrel Sampling of Soils, D 1586-67, American Society for Testing and Materials, Philadelphia, Pennsylvania.

4.2 ASTM Standards, 1980. Standard Method for Thin-Walled Tube Sampling of Soils, D 1587-74, American Society for Testing and Materials, Philadelphia, Pennsylvania.

4.3 Pitcher Drilling Co., date unknown, Pitcher Sampler (brochure), Daly City, California.

5.0 DISCUSSION

None.

6.0 RESPONSIBILITY

6.1 Each individual performing subsurface drilling and sampling of in situ soils for geotechnical investigations shall be responsible for completing the assigned field activities.

6.2 The Field Manager shall be responsible for the following:

- Direct supervision of the drilling and sampling operation and liaison with the drilling contractor(s)
- Ensuring that equipment and materials are provided to expedite and allow for optimum drilling and sampling operations
- Maintenance of quality control of the drilling and sampling operation
- Approval of the daily field work summary and sampling reports.

6.3 The Driller shall prepare daily drilling reports.

6.4 The Golder Geologist/Hydrogeologist on each drill rig shall be responsible for logging the borehole, logging events, receiving 2 and logging samples and reviewing the daily drilling report with the Driller at the end of each shift.

7.0 EQUIPMENT AND/OR MATERIALS

7.1 A drill rig of suitable design, with all accessories, including a motor, rigging, and air compressor, as needed, to provide optimum penetration and sampling of the in situ materials as is required.

7.2 A 2-inch split-tube sampler constructed in accordance with Section 2.2.2 of ASTM D 1586-67. The sampler should have an outside diameter of 2 inches, an inside diameter of 1-1/2 inches, an inside sample tube length of 24 inches, a hardened drive shoe, and a basket retainer.

7.3 A 4-inch split-tube sampler constructed in accordance with Section 2.2.2 of ASTM D 1586-67. The sampler should have an outside diameter of 4-1/2 inches, and inside diameter of 4 inches, an inside sample length of 24 inches, a hardened drive shoe, and a basket retainer.

7.4 A 6-inch split-tube sampler constructed in accordance with Section 2.2.2 of ASTM D 1586-67. The sampler should have an outside diameter of 7 inches, ni ainside diameter of 6 inches, and inside sample length of 24 inches, a hardened drive shoe, and a baskt retainer.

7.5 A Drive Weight Assembly for driving the 2-inch sampler. The assembly shall consist of a 140-pound (63.5 kg) weight, a driving head, and a guide which permits a free fall of 30 inches. Special attention shall be given to ensure that there is no energy loss due to friction between the drive weight and the guide, nor from the rope or wire used to raise the weight.

7.6 A Drive Weight Assembly for driving the 4-inch and 6-inch split-tube samplers. The drive assembly used to advance the 4-inch and 6-inch split-tube samplers shall consist of a casing hammer impacting on an anvil block which has been permanently affixed to a section of drill rod. The assembly shall transmit the full impact of the "casing hammer" through the drill rods to the sampler. The "casing hammer" shall be certified by the contractor as to its proper functioning, and it shall be verified daily to the satisfaction of the Golder Geologist. The casing hammer shall deliver a constant and consistent output of energy.

7.7 A Pitcher Sampler and all accessory parts, including an extra carbide-tipped bit, 36-inch thin-waller Shelby tubes, and plastic caps and wax with which to seal the Shelby tubes.

7.8 A Push Tube sample apparatus, including the push tube adaptor which holds the thin-walled Shelby tubes, and plastic caps and wax with which to seal the Shelby tubes.

7.9 A Drive-Tube Sampler and all accessory parts, including extra drive bits, sand traps and sample extrusion apparatus. The drive assemble is equipped with a down-hole air hammer.

7.10 Hole stabilization equipment and/or techniques to ensure continued penetration as required.

7.11 Generally required drilling equipment, including casing, water truck, and skidder.

8.0 PROCEDURES

8.1 Introduction

8.1.1 All drilling and sampling operations shall be thorough and accurate, and shall follow good drilling practice. All drilling personnel shall be aware of the importance of proper drilling and sampling techniques, health and safety requirements, quality assurance requirements and the purpose of this technical procedure. Unanticipated drilling conditions may dictate changes in standard and accepted drilling procedures as outlined in this technical procedure. The Task Leader shall be responsible for authorization to amend such procedures.

8.2 Drilling Techniques

8.2.1 The unconsolidated deposits that are present create special drilling problems due to the nature of the materials. The drilling techniques used to penetrate and sample this deposit may consist of hollow stem augering or air rotary drill-and-drive methods. The hollow stem augering technique consists of advancing continuous flight augers into the ground and sampling through the augers. This method requires no casing and will be used to penetrate unconsolidated material to a maximum depth of usually 100 feet. The drill-and-drive method continuously employs a tri-cone roller bit or pneumatic down-the-hole hammer to achieve penetration of the materials. Steel casing is advanced directly behind in the open hole using a pneumatic casing hammer. Casing may be telescoped (with a grout plug at the telescoped junction) to attain greater depth or to eliminate cross-contamination between aquifer zones. 2

8.2.2 All casing used in the drilling operations shall be of such design and wall thickness as to prevent collapse or deformation when driven through the in situ materials.

8.2.3 All welding of casing or alternate approved methods of joining the casing shall follow acceptable practices to prevent separation at joints when driven through the in situ materials.

8.2.4 The drilling method shall provide a reasonable opportunity to notice gross material changes and the point at which the phreatic groundwater level is encountered.

8.2.5 The drilling and soil sampling procedures shall start at the ground surface (depth of 0 feet) and continue in 5- 2 foot intervals to the bottom of the hole or as directed by the Golder geologist.

8.2.6 During drilling or well installation, liquid fluids and/or additives to either assist in cuttings removal or for borehole stability shall not be used. Before any fluid and/or additives are used, written approval must be obtained from the Field Supervisor.

2

8.3 Sampling Techniques

8.3.1 In sampling unconsolidated deposits, the sampler shall be advanced in accordance with Section 8.2 above.

The Field Borehole Log (Exhibit A) shall be completed by each individual on a shift with the following information being recorded.

- Surface elevation (if available), depth, drill fluid; beginning of shift data: time, depth to WL; and end of shift data: depth and description of materials encountered, time, depth to WL, hours production/hours delayed.

- Type of equipment in use, such as core barrel/bit size, type, and serial number.

- Notes on all associated drilling activities such as drilling personnel on site, weather conditions, lost time, and all other activities that warrant documentation.

If information for the Field Borehole Log Sheets is not available, it shall be indicated on the sheet by N/A.

8.3.2 The sampler shall be removed from the hole without excess jarring to the sampler when breaking the drill rods. Such jarring may result in the loss of the sample or a portion of the sample. If a sample is lost or poor recovery is realized (defined as more than 50 percent missing from the sampled length), the following procedures shall be undertaken:

- o The sampler shall be lowered down the hole and an attempt shall be made to recover the lost sample
- o If the second attempt was unsuccessful, further attempts to obtain a sample from the interval should be halted and the borehole should be advanced to the next sampling interval.

8.3.3 The hole shall be advanced to the next sample interval using the drill-and-drive method or the hollow-stem auger method as specified in the Work Plan. The hole shall be cleaned out to the bottom of the casing or augers prior to sampling. Neither the bit, casing, nor augers shall be advanced past the sample interval. If, at any time during the drill-and-drive or augering operation, the hole is advanced past the next sampling interval as determined by the Golder Geologist, another hole may be started and advanced to the requested depth. If the hole is caving, however, the Golder Geologist may require the steel casing to be advanced to the top of the sample interval.

8.3.4 After both the drill rods and casing, or augers have been advanced to the next sample interval, the rods and bit shall be removed, the sampler shall be placed on the bottom of the drill rods, and the sampler shall be lowered down into the hole. The driller shall assist the Golder Geologist as required to determine the exact depth of the bottom of the hole prior to bit and rod removal. If the hole has more than 6 inches of cuttings within the casing or augers above the sample interval when the sampler comes to rest at the bottom of the hole, the sampler shall be removed and the hole shall be recleaned.

8.3.5 The sampler shall be placed in hole to the correct depth and the sequence outlined above shall be repeated.

8.4 Split-Tube Sampling

8.4.1 All procedures and techniques used to obtain split-tube samples shall be based upon ASTM D 1586-67, "Penetration Test and Split-Barrel Sampling of Soils."

8.4.2 The 2-inch split-tube sampler shall be driven 18 inches with a 140-point weight as specified in ASTM D 1586-67. It shall be used as the primary sampling tool in nonlithified clays, silts, sands, and fine gravels.

8.4.3 The 4-inch and 6-inch split-tube samplers shall be driven 18 inches with a casing hammer as specified in the drilling and sampling specifications. The 6-inch sampler is to be used at the direction of the Golder Geologist, and is intended to be the sampling tool for zones of coarse gravels and cobbles.

8.5 Pitcher Barrel Sampling

8.5.1 All procedures and techniques used to obtain Pitcher barrel samples shall be based upon ASTM D 1587-74 "Thin-Walled Tube Sampling of Soils," with the exception of Sections 3.3, 3.4, and 3.5. The technique described in the Pitcher Drilling Co. Pitcher Sampler brochure shall be used as a substitute for Sections 3.3, 3.4, and 3.5 above.

8.6 Push Tube Sampling

All procedures and techniques used to obtain push tube samples shall be based upon ASTM D 1587-74 "Thin-Walled Tube Sampling of Soils."

8.7 Drive-Tube Sampling

The 3-inch or 4-inch drive-tube samplers shall be driven 4 feet with a down-hole air hammer or casing hammer as specified in the drilling and sampling specifications. The drive end of the tube sampler will be fitted with a sand/gravel trap for retaining materials. 2

8.8 Documentation

8.8.1 Daily Drilling Reports shall be prepared by the Golder geologist/hydrologist to record daily drilling activity. The Daily Drilling Report shall follow the format as agreed to between the individual contractor and the Task Leader. A data sheet entitled Field Borehole Log (Figure 1) shall be used to record data for each drill hole by the Field Engineer or Geologist. 2

8.8.2 Field drilling records shall be duplicated at the work site and the originals transmitted to the Seattle office on a daily basis. When field work has been completed, all drilling records shall be returned to the Seattle office.

8.8.3 The Project Manager or Project Coordinator shall be responsible for determining the distribution of the drilling records to appropriate personnel. Originals of drilling records shall be retained in the project files.

8.8.4 The Project Coordinator shall verify receipt of all records received from the field by comparing those records with the transmittal form by signing and dating the form. Transmittal forms shall be maintained in the project file.

ADDENDUM

APPLICABLE TO THE WDOE COLBERT LANDFILL PROJECT ONLY, PARAGRAPH 8.2.5 SHALL READ:

8.2.5 The drilling and soil sampling procedures shall start at the ground surface (depth of 0 feet) and will be taken whenever a major change in lithology is noted or as described in the Work Plan.

Approved by: [signature]
Project Sponsor, T. Burgess

4/22/85
Date

Approved by: [signature]
Corporate QA Officer, T. Ashbaugh

4-23-85
Date

Approved by: Douglas L. Morell
Project Manager, D. Morell

4/23/85
Date

Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

TITLE	EFFECTIVE DATE	REV. LEVEL
TP-1.2-6 TECHNICAL PROCEDURE FOR FIELD IDENTIFICATION OF SOIL SAMPLES		
PREPARED BY Douglas J. Moell Feb 11, 1985 APPROVED [signature] 2-11-85 APPROVED [signature] Feb 11/85		4
CONTROLLED DOCUMENT		

Revision Level	Page No.	Section No.	Revision Made TP-1.2-6
4	Page 1	Sect. 3.1	Deleted Rotary Sample throughout procedure.
	Page 2	Sect. 8.3	Deleted "or Project Coordinator".
		Sect. 8.4	Changed Project Coordinator to Project Secretary.

1.0 PURPOSE

This Technical Procedure is to be used to establish uniform and consistent procedures for field identification of soil and rotary samples obtained from subsurface drilling.

2.0 APPLICABILITY

This Technical Procedure is applicable to all persons or parties engaged in the description of soil or rotary samples.

3.0 DEFINITIONS

3.1 Soil Sample. Disturbed or undisturbed soil sample obtained by utilizing the sample techniques outlined in TP-1.2-5, "Drilling and Sampling of Soils for Geotechnical Investigation". 4

4.0 REFERENCES

4.1 ASTM Standards, 1979, Standard Recommended Practice for Descriptoin of Soils (Visual-Manual Procedure), D 2488-69, American Society for Testing and Materials, Philadelphia, PA.

4.2 Golder Associates Manual of Field Identificaiton of Soils (Attachment A).

4.3 Rock-Color Chart, Geological Society of America, Boulder, Colorado.

4.4 Munsell Color Chart, Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C.

5.0 DISCUSSION

None.

6.0 RESPONSIBILITY

6.1 Each Individual as designated by the Project Manager shall be responsible for completing the assigned field identification.

6.2 The Field Manager as designated by the Project Manager shall be responsible for making observations to determine effective implementation of the field identification procedures.

7.0 EQUIPMENT AND MATERIALS

7.1 Small supply of water

7.2 Pocket knife or small spatula

7.3 Small test tube with stopper or glass jar with sealed lid

7.4 Small bottle of dilute hydrochloric acid

7.5 Small hand lens

7.6 Pocket penetrometer or shear gage

7.7 Rock color Chart or Munsell Soil Color Chart

7.8 1/2-in (12-mm) rebar

7.9 5-lb hammer

7.10 Field notebook

7.11 Field drillhole logs

8.0 PROCEDURE

8.1 The procedures used for the field identification of soil samples shall be the procedures and tests as outlined in the Golder Associates Manual of Field Identification of Soils (Attachment A).

8.2 Field drillhole logging records shall be duplicated at the work site and the copies transmitted to the Seattle office on a weekly basis. They shall be accompanied by a transmittal letter delineating the data sent. When field work has been completed, all remaining records shall be returned to the Seattle office.

8.3 The Project Manager shall be responsible for determining the distribution of the drill logging records to appropriate personnel. Originals of drill logging records shall be retained in the project files. 4

8.4 The Project Secretary shall verify receipt of all records received from the field by comparing those records with the transmittal 4 letter by signing and dating the form. Transmittal letters shall be maintained in the project file.

TP-1.2-6

ATTACHMENT A

GOLDER ASSOCIATES

MANUAL OF FIELD

IDENTIFICATION OF SOILS

FOREWORD

The following discussion summarizes Golder Associates' system of soil identification and description of soils in the field. No detailed technical discussion is included; those interested in such should consult the textbooks referenced at the end of this manual. Suggestions for improvement of the techniques described in this manual are welcome.

TABLE OF CONTENTS

1.0 DETERMINATION OF SOIL COMPOSITION

1.1 GENERAL

1.1.1 For purposes of soil description, the material is considered to be composed of the coarse fraction or of particles larger than the No. 200 sieve (+.074 mm) and the fine fraction or those smaller than the No. 200 sieve. The coarse fraction is described based on its particle size while the fines are described based on its plasticity.

1.1.2 The following terminology is used to denote the pecentage by dry weight of each soil component:

Descriptive Term	Range of Proportion
"Trace"	1-10%
"Some"	10-20%
Adjective (sandy, silty, etc.)	20-35%
"and"	35-50%

For example: "sandy SILT, some gravel, trace clay" describes a basic soil component of silt (35-50%), with minor components of sand (20-35%), gravel (10-20%), and clay (1-10%).

1.1.3 Soil composition should be described with the pre-dominant grain size first (indicating coarse, medium, or fine for sands and gravels), followed by "trace", "some", and maximum size notation. All major soil constituents should be capitalized. The following abbreviations are acceptable:

c = coarse
m = medium
f = fine

1.2 FIELD IDENTIFICATION TESTS - FINES

1.2.1 General - The fine fraction description is based on its plasticity as follows:

Silt: non-plastic; PI<2 percent

Clayey silt: low plasticity; PI:2-15 percent

Silty clay: moderate plasticity; PI:15-40 percent

Clay: high plasticity; PI>40 percent

where PI is the plastic index or the liquid limit minus the plastic limit.

1.2.2 Field Test for Plasticity - Plasticity refers to the ability of a material to be deformed rapidly without cracking or crumbling and them maintain that deformed shape after the deforming force has been released. A soil is said to be highly plastic if there is a wide range of moisture content over which it remains in the plastic state. High plasticity indicates a high clay content. Identification of cohesive soils in relation to their plasticity can be made on the following basis: The natural soil is worked until its moisture content is such that a 1.5-inch diameter ball formed from the soil shows a flattened contact surface of 7/8-inch diameter when dropped from a high of 2 feet (gravel sizes are not included in the ball). The smallest thread possible without crumbling is then rolled from the above soil sample. The approximate relationships below are then used for identification.

Thread Diameter	Descriptive Term
1/4 inch	SILT
1/8 to 1/16 inch	clayey SILT
1/32 inch	silty CLAY
1/64th inch	CLAY

1.2.3 Dry Strength - A portion of the soil is allowed to dry out completely in air. An angular fragment (about 1/2-inch) of the dried soil is pressed between the fingers. The dry strength of the fragment is expressed as very low, low, medium, high and very high. Fragments with very high strength cannot be injured at all, whereas those of very low strength disintegrate completely on gentle pressure. The strength is called medium if the fragment can be reduced to powder only with great effort. Those materials with greater dry strengths are predominantly clayey, and those with less dry strength are predominantly silty.

1.2.4 Stickiness. A high degree of stickiness in the natural state is indicative of higher plasticity.

1.2.5 Shine Test. If a moist lump of soil is stroked with considerable pressure with the flat of a pen knife blade or fingernail, the type of surface imparted is an indication of the soil: if a shiny surface results, the presence of clay is indicated; silt is indicated if a dull surface is produced.

1.2.6 Grittiness Test. When a small amount of soil is placed between the teeth, the presence of grit will indicate silt or sand, but if no grit is detected, a pure clay is present.

1.2.7 Organic cohesive soils. Organic cohesive soils display the following characteristics:

- A dark-brown, dark-gray, or black color indicates the presence of organic matter.
- An odor of decaying vegetation is typical. If organiz matter cannot be distinguished, it can somtimes be brought out by a light amount of heat.
- The presence of fibrous or root structures, twigs, leaves, or shells is common.

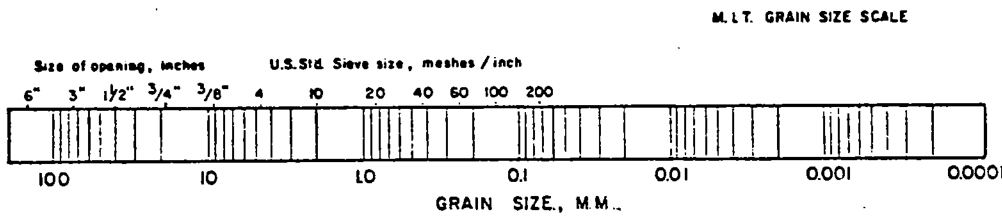
- o At least a 3/4 reduction in the liquid limit value after oven-drying is considered positive identification of organic soil.
- o The plasticity of fine-grained organic soils is greatly reduced on oven-drying due to irreversible changes in organic colloids.
- o Organic clays feel spongy in the plastic range as compared to inorganic clays.

1.3 FIELD IDENTIFICATION TESTS - COHESIONLESS SOILS

1.3.1 Visual Identification of Grain Size. The consituent parts of a soil sample are defined by grain size, as indicated in the table below:

TABLE 1-1

GRAIN-SIZE SCALE



COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

Utilizing Table 1-1, the following soil types are defined.

- o Boulders: larger than 8 inches in diameter.
- o Cobbles: 2-1/2 to 8 inches in diameter.
- o Gravel: smaller than 2-1/2 inches in diameter and larger than a No. 10 sieve.
- o Sand: particles larger than a No. 200 sieve but smaller than a No. 10 sieve. All sand particles are visible to the naked eye. A hand sample of sand when spread out across the palm of the hand will allow each individual particle to be observed and will present a "clean" appearance. If silt is present, it will tend to stick together and "dirty" the hand.

1.3.2 Grittiness Test. The soil is handled lightly between the thumb and forefinger to get an idea of the grittiness or softness of the soil. A pinch of uncontaminated soil is smeared with considerable pressure beteween the thumb and forefinger to determine the degree of harshness and grittiness. When a small amount of uncontaminated soil is placed between the teeth, the presence of grit will indicate silt or sand, but if no grit is detected, an almost pure clay is present.

- Coarse to medium sand exhibits a typically harsh and very gritty feel and smear.
- Coarse to fine sand has a less harsh feel but exhibits a very gritty smear.
- Medium to fine sand exhibits a less gritty feel and smear.
- Fine sand has a softer feel and a much less gritty smear.

1.3.3 Test Tube Test. A small sample of the soil (lumps are first broken up) is shaken in a test tube or glass jar filled with water and is allowed to settle. All the fine sand will settle out (4-inch fall) in 30 seconds; the silt in 50 minutes. A rough idea of the grain sizes can be obtained by this test.

1.3.4 Dilatancy Test. When a wet pat of soil is shaken vigorously in the hand, the surface will become glassy and show free water. If the pat of soil is then squeezed in the fingers with the free water disappearing and the surface becomes dull, the soil is NOT a clay soil, but a silt or fine sand. If the free water on the surface disappears immediately (as walking on the beach adjacent to the water), the soil is most likely a fine sand. If the free water tends to ooze away, the soil is most likely silt.

1.3.5 Organic Soil - Peat. Peat is usually dark brown to black; contains fibrous particles of vegetation in varying states of decay; has characteristic organic odor; is usually spongy and compressible; commonly contains natural moisture contents of over 100 percent and can contain organic and inorganic silts and clays in varying amounts and concentrations.

1.4 DETERMINATION OF SOIL TYPES

1.4.1 Based on the tests and observations described in the previous text, the soil description can be made by compiling the properties of the soil and comparing them to Table 1-2.

TABLE 1-2

DESCRIPTION OF SOIL BASED ON OBSERVATION AND TESTS

TYPICAL NAME	DESCRIPTION
Boulders	Larger than 8 inches in diameter
Cobbles	2-1/2 to 8 inches in diameter
Gravel	1/16 to 2-1/2 inches in diameter
Coarse to Fine Sand	All particles are visible to the naked eye

	Dilatancy Test	Test Tube Test	Plasticity	Dry Strength	Stickiness	Shine Test
fine Sand	rapid	30 sec	none	extremely	none	none
Silt	moderate	50 min	none	very low	none	none
Silt	slow	+50 min	slight	low	none	none
clayey Silt	none	hours	medium	low to medium	slight	smooth & dull
silty Clay	none	hours	high	medium to high	moderate to high	moderately slick & smooth
Clay	none	+24 hrs	very high	high to very high	high to very high	slick & waxy
organic Silt	moderate	$\pm$ 50 min	slight to medium	low	none	dull & silky
organic Clay	none	$\pm$ 24 hrs	medium to high	medium to high	moderate to high	dull, smooth & silky

2.0 DETERMINATION OF CONSISTENCY OR RELATIVE DENSITY

2.1 "N" values, the standard penetration test (SPT), or number of blows required by a 140-pound hammer or weight dropped 30 inches to drive a 2-inch O.D. (1-3/8 in. I.D.) drive-open sampler will indicate the relative density of cohensionless soils and the consistency of cohesive soils. The standard test penetrates 18 inches. "N" values are the blows required to drive the sampler the last 12 inches. The blows required to drive the sampler the first 6 inches are not taken into account. Blows are recorded for each 6-inch interval. Table 2-1 should be used to determine the relative density or consistèncy based on standard penetration test values.

TABLE 2-1

RELATIVE DENSITY OR CONSISTENCY
UTILIZING STANDARD PENETRATION TEST VALUES

Cohesionless Soils*		Cohesive Soils**	
Relative Density	N, blows/ft	Consistency	N, blows/ft
Very loose	0 to 4	Very soft	0 to 2
Loose	4 to 10	Soft	2 to 4
Compact	10 to 30	Firm	4 to 8
Dense	30 to 50	Stiff	8 to 15
Very Dense	over 50	Very Stiff	15 to 30
		Hard	over 30

* Soils consisting of gravel, sand, and silt, either separately or in combination, possessing no characteristics of plasticity, with average particle diameter greater than 0.002 millimeters.

** Soils consisting generally of the Clay fraction, possessing the characteristics of plasticity with an average particle diameter of less than 0.002 millimeters.

2.2 In Table 2-2, standard penetration test values are correlated with diagnostic features of cohensionless and cohesive soils.

TABLE 2-2

SOIL DESCRIPTION UTILIZING STANDARD PENETRATION TEST VALUES

Cohesionless "N"		Cohesionless Diagnostic Features	Cohesive "N"		Cohesive Diagnostic Features
0	Very Loose		0	Very Soft	Easily penetrated several inches by fist. Exudes from between fingers when squeezed.
4	Loose	Easily penetrated with 1/2 inch rebar pushed by hand. Easily excavated with hand shovel.	2	Soft	Easily penetrated several inches by thumb. Molded by light finger pressure.
10	Compact	Easily penetrated with 1/2 inch rebar driven with 5 lb. hammer. Difficult to excavate with hand shovel.	4	Firm	Molded by strong finger pressure.
30	Dense	Penetrated one foot with 1/2 inch rebar driven with a 5 lb. hammer. Must be loosened with pick to excavate.	8	Stiff	Indented by thumb.
50	Very Dense	Pentrated only a few inches with a 1/2 inch rebar driven with a 5 lb. hammer.	15	Very Stiff	Readily indented by thumbnail.
			30	Hard	Difficult to indent by thumbnail.

3.0 DEFINITIONS OF STRUCTURAL CHARACTERISTICS

3.1 Stratified: Composed of, or arranged in, layers. Applies to granular soils. The layers are usually thicker than one inch, parallel to one another, and composed of soils visibly different from each other.

3.2 Layered: Usually applied to cohesive soils. The thickness of individual layers varies from fractions of an inch up to several inches.

3.3 Parting: Paper-thin separation of one soil type within another. Usually applied to cohesive soils.

3.4 Varved: Consisting of alternate thin layers of sand, silt or clay. Each layer generally less than 1/2-inch in thickness. Applies to soil deposited in a glacial environment.

3.5 Lenses: A particular soil type exclusively different from the surrounding soils. A lense is usually small in dimension, several inches at the most, and is applied to granular soils.

3.6 Pocket: An unexpected soil type of limited thickness found in a boring. Can be applied to all soil types.

3.7 Homogenous: Of uniform structure.

3.8 Heterogenous: Consisting of dissimilar constituents; mixed.

3.9 Mottled: Shows the presence of spots, streaks or splotches of one or more colors in a soil mass of another predominant color. In mottled soils, the colors are not mixed and blended, but each is more or less distinct in the general ground color.

3.10 Slickensided: A polished and scratched surface that results from friction along a fault plane. A slickensided surface looks like a piece of corrugated metal.

4.0 DEFINITIONS OF GENERAL GEOLOGIC DESCRIPTIONS

4.1 Alluvial Soil: Any soil that has been deposited by stream transportation. Such soils usually contain some sand and rounded gravel or cobbles. The cross-section plot of the logs will show that the layers frequently thicken, thin, or pinch out.

4.2 Glacial Till: A non-stratified random mixture of clay, silt, sand, gravel and boulders deposited by glaciers. Alternating layers of clayey till and till containing boulders are possible.

4.3 Outwash: A stratified glacial deposit that is streambuilt as a result of the melt water carrying soil from a glacier.

4.4 Loess: A uniform aeolian (wind) deposit of silty material having an open structure and relatively high cohesion due to cementation of clay or calcareous material at grain contacts. A characteristic of loess deposits is that they display nearly vertical slopes.

4.5 Residual Soil: Soils that have formed in place due to the decomposition of rock. Shales form residual clays. Limestone form lean brown and fat red clays. Granitic rocks form silty sand with angular sand grains.

5.0 DETERMINATION OF COLOR

Color can be an important property in identifying materials of similar geologic origin. Color is an important property in identifying organic soils. Although qualitative color names are somewhat helpful, positive color identifications obtained by comparison with a standard color chart are even more useful. If the sample contains layers or patches of varying colors, this should be noted and all representative colors should be described. If possible, color should be described for moist samples. Charts especially prepared for describing the colors of soil and rock are available. Such charts give typical descriptive names for the color chips and the correct Munsell color notation in terms of hue, value and chroma (example: Pind [Moderate orange pink] 5 YR 8/4).

6.0 MINOR AND/OR USUAL CHARACTERISTICS

Minor characteristics of the soil sample should be included in its description. These characteristics include: occasional traces of organic debris, mention of other types of deleterious materials such as a trash or cinder fill, portions of cobbles or boulders received in the sampler, anmd pockets and/or lenses of material other than those already mentioned in the description.

7.0 DETERMINATION OF MOISTURE CONTENT

Although moisture content is <u>not</u> generally included in the identification of soils in the field because of the difficulty in obtaining a numerical quantity, a general qualitative description can be applied if necessary. The following descriptions can be used:

- o Dry: No discernible moisture present
- o Damp: Enough moisture present to darken the appearance, but no moisture on material adheres to the hand
- o Moist: Will moisten the hand
- o Wet: Visible water present; plastic materials will leave sticky residue in hand when remolded.

8.0 REACTION TO DILUTE HYDROCHLORIC ACID

Some soils show definite evidence of cementation in the intact state. Where this is noted, the degree of cementation may be described as weak or strong. Since calcium carbonate is the most common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important. The intensity of the HCl reaction should be described as none (NR), weak (WR), or strong (SR).

9.0 GENERAL DESCRIPTIVE SEQUENCE OF PARAMETERS USED IN DESCRIBING SOIL SAMPLES

9.1 Table 9-1 contains a list of the general descriptive sequence of parameters used in describing soil samples and lists the section in this manual which discuss these parameters.

TABLE 9-1

Category	Parameter	Described in
1.	Consistency (or Relative Density)	Section 2.0
2.	Color	Section 5.0
3.	Structural Characteristic	Section 3.0
4.	Composition	Section 1.0
5.	Minor Characteristics	Section 6.0
6.	General Geologic Description	Section 4.0
7.	Moisture content	Section 7.0
8.	Reaction to Dilute Hydrochloric Acid	Section 8.0

9.2 An example of a soil sample description follows. The numbers refer to categories above. All major soil consitutuents, structural characteristics, and general or geologic description should be capitalized.

```
    (1)     (2)     (3)
Very Dense, gray, STRATIFIED

        (4)
Fine to medium SAND and fine GRAVEL, maximum size 1", trace silt

            (5)
with occasional fine clay seams

         (6)     (7) (8)
(RECENT ALLUVIUM), dry, NR
```

REFERENCES

1. Soil Classification, a Comprehensive System, the Seventh Approximation, U.S. Department of Agriculture, Washington, 1960.

2. Soil Survey Manual, Handbook 18, U.S. Dept. of Agriculture, Washington, 1951 (and 1962 Supplement).

3. "Glossary of Pedologic and Landform Terminology", Special Report 25, Highway Research Board, Washington, 1957.

4. A. Casagrande, "Classification System, Transactions, ASCE, 1948, p. 901.

5. Unified Soil Classification System, Technical Memorandum 3-357, U.S. Waterways Experiment Station, Vicksburg, 1953.

6. ASTM Standard, D 2487-66T, "Classification of Soils for Engineering Purposes", ASTM Standards, Part 11, ASTM, Philadelphia, 1969.

7. K. Terzaghi and R.B. Peck, Soil Mechanics in Engineering Practice, John Wiley & Sons, Inc., New York, 1948, p. 31.

8. L.F. Cooling, A.W. Skempton, and R. Glossop, Discussion, of Reference 4.

9. Munsell Soil Color Charts, Munsell Color Company, Inc., Baltimore, 1954.

10. Glossary of Geology and Related Sciences, American Geologic Institute, National Academy of Sciences, Washington, 1957.

11. PCA Soil Primer, Portland Cement Association, Chicago.

12. D.M. Burmister, "Identification and Classification of Soils", Symposium on Identification and Classification of Soils, ASTM Special Publication 113, Philadelphia, 1951.

APPENDIX A

LIST OF TERMS

Plastic Limit: The moisture content at which a thread of soil 1/8-inch in diameter will begin to crumble when rolled further. Near the plastic limit, highly plastic soils will require considerable pressure to roll threads by hand and medium plastic soils will require a noticeable pressure. Weakly plastic soils can be rolled with little effort.

Liquid Limit: The water content corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil. The water content at which a pat of soil, cut by a groove of standard dimensions, will flow together for a distance of 1/2-inch under the impact of 25 blows in a standard liquid limit apparatus.

Plastic Index: The numerical difference between the liquid limit and the plastic limit.

Grading: The term applied to the particle-size distribution of the soil. A uniform soil has a predominance of particles of one size, whereas a well-graded material has sizes assorted over a wide range, with no one size predominating. The word "uniform" is applied where it is obvious that one size is predominant, and "graded" if this is not the case.

Compressibility: Property of a soil pertaining to its susceptibility to decrease in volume when subjected to load.

Consolidation: The gradual reduction volume of a soil mass resulting from an increase in compressive stress.

Void Ratio: The ratio of (1) the volume of void space to (2) the volume of solid particles in a given soil mass.

APPENDIX B

<u>LIST OF ABBREVIATIONS/SYMBOLS TO BE USED ON THE FIELD COREHOLE/BOREHOLE LOGS</u>

1.1

Soil Types	Color	Stratigraphy
Fill	Black	
Sand	Yellow	
Sand & gravel	Blue	
Gravel	Blue	
Cobbles & boulders	Blue	
Silt	Orangw	
Clay	Light green	
Organic	Brown	

NOTE: The above color and symbolism used to depict the soil or rock in the graphic log column of the field corehole/borehole log <u>must</u> follow the major identified constituent. Symbolism for the minor identified constituent should be indicated by broken or partial lines of the identified material.

1.2

Rock Types	Color	Stratigraphy
Ash	Pink	
Tuff	Pink	
Basalt	Red	

1.3 SAMPLE DESCRIPTION

DISTURBED

FAIR

GOOD

LOST

1.4 SAMPLE TYPES

A.S. - AUGER SAMPLE

C.S. - CHUNK SAMPLE

D.O. - DRIVE OPEN (note: I.D.)

D.S. - DENISON TYPE SAMPLE

F.S. - FOIL SAMPLE

R.C. - ROCK CORE

T.P. - THIN-WALLED, PISTON

T.B. - THIN-WALLED, PITCHER SAMPLER

W.S. - WASH SAMPLE

1.5 PENETRATION RESISTANCES

N - (Standard Penetration Resistance) The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch O.D. drive open sampler 1 foot.

WH - Sampler advanced by static weight - weight, hammer.

PH - Sampler advanced by pressure - pressure hydraulic.

PM - Sampler advanced by pressure - pressure manual.

1.6 MISCELLANEOUS ABBREVIATIONS

SA. - SAMPLE

CA. - CASING

WL. - WATER LEVEL

V - IN SITU VANE SHEAR TEST

Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

TITLE TP-1.2-12 TECHNICAL PROCEDURE FOR MONITOR WELL DRILLING AND INSTALLATION			EFFECTIVE DATE	REV. LEVEL
PREPARED BY Douglas J. Morell Feb. 11, 1985	APPROVED [signature] 2-11-85	APPROVED [signature] Feb 11/85		1
David L. Smith June 10, 1985	[signature] 6-10-85	[signature] June 11/85		2
	CONTROLLED DOCUMENT			

Revision Level	Page No.	Section No.	Revision Made TP-1.2-12
2	Page 2	Sect. 7.5	Added.
		Sect. 7.6	Added.
	Page 3	Sect. 8.2	Deleted last sentence.

1.0 PURPOSE

This technical procedure is to be used to establish a uniform procedure for installing monitor wells.

2.0 APPLICABILITY

This technical procedure is applicable to all persons or parties involved with installation of monitor wells.

3.0 DEFINITIONS

3.1 Monitor Well. A well completed within a zone of interest and of sufficient diameter to allow sampling and pump testing.

3.2 Bentonite. An expanding clay.

3.3 Well casing. A pipe used to line a borehole to prohibit caving and/or prevent direct flow from the formation into the borehole.

3.4 Grout. A cement mixture which is originally fluid enough to flow through tremie pipes, it is used to seal casing within a borehole. Specifications are given in 7.10.

3.5 Well screen. A perforated or slotted pipe which allows flow of water from the formation into the borehole.

4.0 REFERENCES

4.1 Gibson, U.P. & Singer, R.D., 1971, Water Well Manual, Premier Press, California.

4.2 Anderson, K.E., 1979, Water Well Handbook, Missouri Water Well & Pump Contractors Assn., Inc. Missouri.

5.0 DISCUSSION

None.

6.0 RESPONSIBILITY

6.1 Each Field Engineer installing monitor wells shall be responsible for proceeding in compliance with this technical procedure.

6.2 Task Leader shall be responsible for:

- Selecting location of boreholes at the site and determining depth and details of completion of monitor wells,
- Direct supervision of personnel drilling boreholes and making well completions,
- Assurance that equipment and material are available to permit accomplishment of the task
- Selection and contracting of services of drilling subcontractors
- Scheduling
- Providing guidelines or specific work instructions for technical requirements beyond the scope of the applicable technical procedure,
- Review and approval of daily work reports,
- The completion of drilling operations and well installation to the satisfaction of Golder Associates' policies of quality, and, to the Client, the Project Review Board, the Quality Assurance Program requirements and other regulatory bodies as applicable.

7.0 EQUIPMENT AND MATERIALS

7.1 A drill rig of suitable design with all accessories, including a motor, rigging, and water pump to provide optimum penetration of the in situ materials as may be required

7.2 Steam cleaner for cleaning drilling equipment between holes

7.3 Hole stabilization equipment and/or techniques to ensure continual penetration as may be required

7.4 Generally required drilling accessory equipment, including water truck and casing

7.5 Pea gravel

7.6 Coarse sand

7.7 Bentonite powder and/or Bentonite compressed pellets

2

7.8 Bentonite slurry (approximately 2 lb. bentonite to 1 gal. of water)

7.9 Grout pump/mixer

7.10 Grout (Portland Type I and II cement; 4 lb. bentonite powder per cubic yard of mixed grout; water shall be added initially at the ratio of 6 gallons per 94 lb. sack of cement. If the grout is too thick to pump, additional water will be added until the grout becomes just pumpable).

7.11 Casing that is 2-inch inside diameter, PVC with flush threaded coupling, schedule 40

7.12 Well screen (2-inch and flush threaded) with 0.02-inch factory matching screen slots)

7.13 History of Hole forms

7.14 Clipboard

7.15 Field notebook

7.16 Folding rule

7.17 Depth Sounder

7.18 Teflon tape

8.0 PROCEDURE

8.1 Drilling will proceed with a "drill-and-drive" method using air-rotary drilling for the entire depth of the hole. The first section of casing shall be equipped with a drive shoe. Casings may be telescoped to attain greater depth or to eliminate cross-contamination between aquifer zones. All drilling equipment will be steamed cleaned between boreholes.

8.2 The Field Engineer will sample drill cuttings and record the history of hole. After intercepting the water table, the Field

Engineer will estimate and record the rate of water production with depth. 2

8.3 During drilling or well installation, fluids and/or additives to either assist in cuttings removal or for borehole stability shall not be used. Before any fluid and/or additives are used, written approval must be obtained from the Field Supervisor.

8.4 When the hole has been drilled to the total depth, withdraw the drill rods. The wells will be constructed as shown in Figures 1 and 2 for a single completed well and a multiple completed well, respectively. No glues or solvent shall be used on the well casing or screens. All coupling will be threaded together with teflon tape wrapped around the threads to prevent leakage. All drive casing (steel) will be removed from the borehole that is adjacent to well screens.

8.5 The objective of the completed wells are as follows:

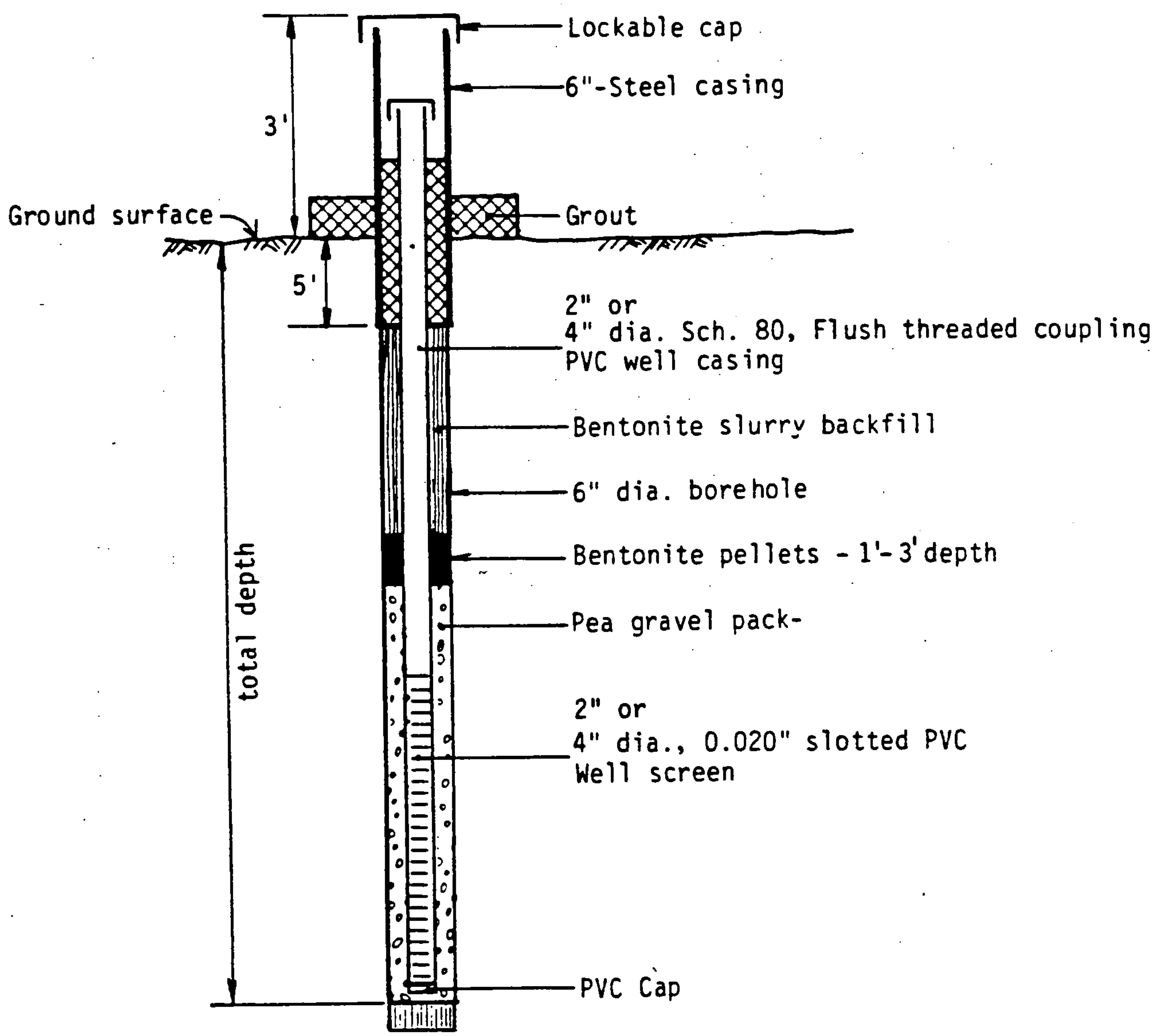
- o the only section (interval) of the completed well which has well screens and a sand and gravel pack will be adjacent to the particular aquifer zone to be monitored.
- o All other sections will be sealed with a bentonite slurry that will be tremie pipe pumped through to the appropriate locations or with bentonite pellets that will be compacted in place.
- o The upper most 5 to 8 feet of the borehole annulus will be filled with a cement grout.

8.6 During completion all backfilled materials and depths of well screens will be sounded with a measuring tape with attached weight on the sounding end.

8.7 The hole will be surged with air to develop communication with the formation. The Field Engineer shall determine when adequate well development has been achieved.

GENERALIZED SCHEMATIC DIAGRAM OF COMPLETED SINGLE WELL CONSTRUCTIONS

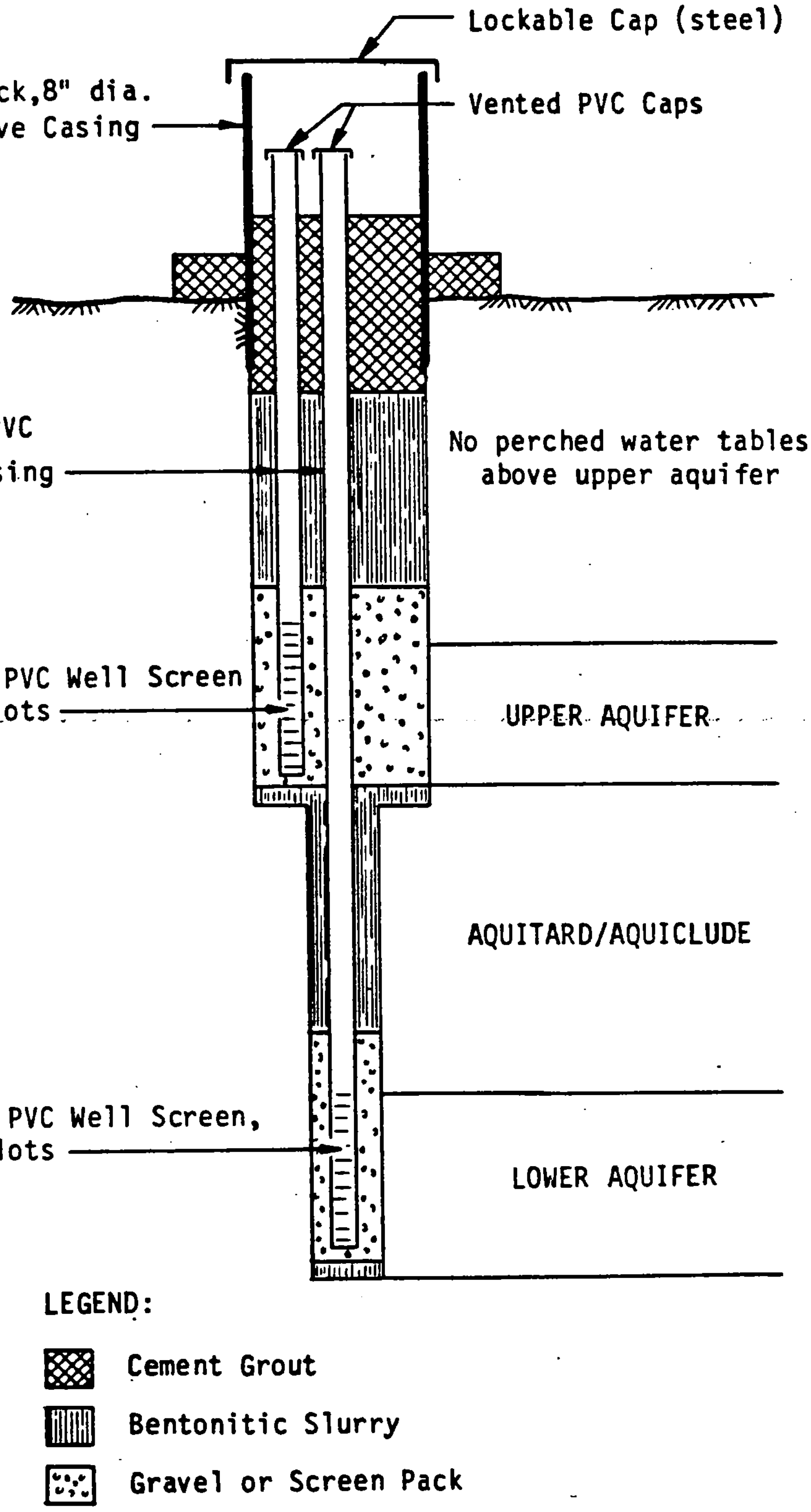
Figure 1



Rev. ____ Dwg. No. 843-1312 Date 12/27/84 Eng. DM

SCHEMATIC DIAGRAM OF WELL COMPLETIONS WITHIN A SINGLE BOREHOLE

Figure 2



Rev. ____ Dwg. No. 843-1912 Date 02/7/85 Eng. ____

Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

TITLE TP-1.2-14 TECHNICAL PROCEDURE FOR COLLECTION GROUNDWATER QUALITY SAMPLES	EFFECTIVE DATE	REV. LEVEL
PREPARED BY Douglas J. Mould Feb 11, 1985 APPROVED [signature] 2.11.85 APPROVED [signature] Feb 11/85		1
CONTROLLED DOCUMENT		

Revision Level	Page No.	Section No.	Revision Made TP-1.2-14
1	Page 1	Sect. 3.1	Deleted Bailer.
			Added Submersible pump or submerisble bladder pump.
		Sect. 4.3	Added.
	Page 2	Sect. 7.1	Deleted PVC Bailer, added diaphragm pump.
		Sect. 7.3	c) Deleted EH meter and e) alkalinity titration apparatus.
		Sect. 7.10 through Sect. 7.15	Added.
	Page 3	Sect. 8.0 to end.	Revised substantially.

1.0 PURPOSE

This technical procedure is to be used to establish a uniform procedure for collecting water quality samples.

2.0 APPLICABILITY

This technical procedure is applicable to all persons or parties involved with collecting water quality samples.

3.0 DEFINITIONS

3.1 Submersible pump or submersible bladder pump. A device for removing water from a well by push (positive pressure) water to the surface when operated below the well's water level. Operates either by electricity or air pressure.

3.2 Well Bore Storage Volume. The volume of water enclosed by the well casing at equilibrium.

4.0 REFERENCE

4.1. U.S. EPA (1977), Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities, Publication SW-611, Solid Waste Management Series, Cincinnati, OH 45268.

4.2 Wood, W.W. (1976), Guidelines for Collection and Field Analysis of Ground-Water Samples for Selected Unstable Constituents, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 1, Collection of Water Data by Direct Measurement, Chapter D2.

4.3 U.S. EPA, 1980 (revised 1982), Test Methods for Evaluating Solid Waste - Physical/Chemical Methods. Office of Solid Waste, Publication SW-846, Washington, D.C.

5.0 DISCUSSION

None

6.0 RESPONSIBILITY

6.1 The field engineer is responsible for sample collection, preservation, field testing, total and accurate completion of data sheets, sample shipment and delivery of the original data to the Task Leader, all as described in this Technical Procedure.

6.2 The task leader is responsible for the conception of the sampling program, for supervising the field engineer, for arranging the logistics of the program and for retrievable and safe storage of the original data.

7.0 EQUIPMENT AND MATERIALS

7.1 Diaphragm pump or bailer and assessories of small enough diameter to enter the well (all materials in contact with the sample shall be either teflon, stainless steel or glass).

7.2 Sample bottles, labels, and preservatives appropriate for the parameters to be sampled (see Tables 5-1 and 6-1).

7.3 Field test equipment

a) thermometer

b) pH meter and standards

c) conductivity meter and standards

7.4 Filtration apparatus (0.45 micron)

7.5 Depth to water measuring device

7.6 Well specifications

7.7 Sample integrity sheets

7.8 Carbon paper

7.9 Field book

7.10 Chain-of Custody forms

7.11 Coolers and ice packs

7.12 Distilled or de-ionized water

7.13 Cleaning equipment and solutions

7.14 Indelible ink pens

7.15 Air pressure source and associated equipment

8.0 PROCEDURES

8.1 Before the pump is lowered into each well for sample acquisition, the pump and sample tube shall have tap water with detergent flushed, through the system. The pump and sample tube will then be immediately rinsed with tap water followed by a final rinse with distilled water.

8.2 Before collecting the actual sample, a minimum of three (3) well bore storage volumes of water shall be purged from the well by pumping. Calculate this volume by measuring the depth to water and subtracting this depth from the total depth of the well.

8.3 Once the sample is collected, the sampler shall note and record color and turbidity of a sample aliquot.

8.4 Samples for volatile organics shall be pumped from the well using positive pressure pump or a bailer and will be collected directly from the sample tube into a 40 ml glass vial to overflow approximately 2 to 3 vial volumes. These samples will not be filtered. Contact with the atmosphere must be minimized. Immediately a teflon lined silicon septum cap will be tightened on to the vial. There shall be no air bubble remaining within the vial once the cap has been fastened tight, otherwise a new sample will need to be taken by the same procedure.

8.5 Samples for base-neutral and pesticide analyses will be collected directly into a 500 ml glass bottle with a teflon lined lid. If the samples are turbid, filtering may be desirable but should be filtered only through fiber glass type or other non-absorbent and/or non-reactive filters to organic constituents.

8.6 Samples for inorganic analyses will be collected within a 1 gallon high density linear polyethylene bottle from the sample tube. Aliquots will be filtered (final shall be a 0.45 micron) and collected in appropriate sample bottles with preservatives (see Table 6-1).

8.7 A pocket thermometer is used to measure the temperature of the water on an aliquot within 3 minutes of sampling. The thermometer reading is allowed to stabilize and is recorded to the nearest degree centigrade.

8.8 A pH meter is used to measure the pH of the sample on an aliquot within 2 hours of sampling. Before each reading, the probe is thoroughly rinsed with distilled or de-ionized water. The pH is read to one-tenth of a pH unit.

8.9 A YSI Model 33 S-C-T with a YSI 3300 Conductivity/Temperature Prove is used for conductivity measurement on an aliquot within 2 hours of sampling. The meter is zeroed and "red-line" adjusted before any measurements are made. The conductivity is then read to three significant figures and the temperature of the sample at the time of conductivity measurement is also recorded.

8.10 Sample integrity sheets and chain-of-custody sheets shall be filled out in indelible ink. Copies of the chain-of-custody sheets shall be included with the sample sent to the laboratory. The original shall be delivered to the task leader.

8.11 All samples shall be stored in the dark at $4^{o}C$ (ice cooler). The ice cooler shall have a seal attached. The samples will be either personally delivered or air freighted to the analytical laboratory.

8.12 The beakers and other laboratory instruments shall be kept clean at all times by rinsing with distilled or de-ionized water before and after use.

Golder Associates
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TITLE	EFFECTIVE DATE	REV. LEVEL
TP-1.2-15 TECHNICAL PROCEDURE FOR COLLECTING WATER QUALITY SAMPLES FROM PRIVATE SUPPLY WELLS		
PREPARED BY Douglas J. Morell Feb 11, 1985 APPROVED [illegible] 2-11-85 APPROVED [illegible] Feb 11/85		Ø
CONTROLLED DOCUMENT		

1.0 PURPOSE

This Technical Procedure is to be used to establish a uniform procedure for collecting water samples from private supply wells to assess drinking water quality. The existing pump and system will not be removed or altered, respectively.

2.0 APPLICABILITY

This Technical Procedure is applicable to all persons or parties involved with collecting water quality samples from private supply wells without removing existing pumps or altering the existing system.

3.0 DEFINITIONS

3.1 Well Head: The top of the casing of a groundwater well at the surface of the ground.

3.2 Well Bore Storage Volume: The volume of water enclosed by the well casing at equilibrium.

4.0 REFERENCES

4.1 U.S. EPA, 1977. Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities, Publication SW-611, Solid Waste Management Series, Cincinatti, OH 45268.

4.2 Wood, W.W., 1976. Guidelines for Collection and Field Analysis of Ground-Water Samples for Selected Unstable Constituents, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 1, Collection of Water Data by Direct Measurement, Chapter D2.

4.3 U.S. EPA, 1980 (revised 1982). Test Methods for Evaluating Solid Waste - Physical/Chemical Methods. Office of Solid Waste, Publication SW-846, Washington D.C.

5.0 DISCUSSION

None.

6.0 RESPONSIBILITY

6.1 Each Field Engineer is responsible for sample collection, preservation, field testing, total and accurate completion of data sheets, sample shipment and delivery of the original data to the Task Leader, all as described in the Technical Procedure.

6.2 Task Leader is responsible for the conception of the sampling program, for supervising the field engineer, for arranging the logistics of the program and for retrievable and safe storage of the original data.

7.0 EQUIPMENT AND MATERIALS

7.1 Diaphragm pump and assessories of small enough diameter to enter the well (all materials in contact with the sample shall be either teflon, stainless steel or glass).

7.2 Sample bottles, labels, and preservatives appropriate for the parameters to be sampled (see Tables 5-1 and 6-1).

7.3 Field test equipment

- a) thermometer
- b) pH meter and standards
- c) conductivity meter and standards

7.4 Filtration apparatus (0.45 micron)

7.5 Depth to water measuring device

7.6 Well specifications

7.7 Sample integrity sheets

7.8 Carbon paper

7.9 Field book

7.10 Chain-of Custody forms

7.11 Coolers and ice packs

7.12 Distilled or de-ionized water

7.13 Cleaning equipment and solutions

7.14 Indelible ink pens

7.15 Air pressure source and associated equipment

8.0 PROCEDURE

8.1 The sampler must inspect the type of pump and water supply system operative for each resident. The most suitable sampling location must be determined and documented in the field log book by the sampler. This shall be the closest discharging water to the well head. An estimate of the static standing well volume of water and the amount of static system water from the well head to the sampling port must be estimated. The logic for such estimates must be well documented within the field log book.

8.2 Before collecting the actual sample, a minimum of three well bore and involved system storage volumes of water shall be purged from the well through the involved system by the existing pump.

8.3 Once the sample is collected, the sampler shall note and record color and turbidity of a sample aliquot.

8.4 Samples of volatile organics will be collected directly from the sample tube into a 40 ml glass vial to overflow. These samples will not be filtered. Contact with the atmosphere must be minimized. Immediately a teflon lined silicon septum cap will be tightened on to the vial. There shall be no air bubble remaining within the vial once the cap has been fastened tight, otherwise a new sample will need to be taken by the same procedure.

8.5 Samples for base-neutral and pesticide analyses will be collected directly into a 500 ml glass bottle with a teflon lined lid. These samples will not be filtered.

8.6 Samples for inorganic analyses will be collected within a 1 gallon high density linear polyethylene bottle from the sample tube. These samples will not be filtered.

8.7 A pocket thermometer is used to measure the temperature of the water on an aliquot within 3 minutes of sampling. The thermometer reading is allowed to stabilize and is recorded to the nearest degree centigrade.

8.8 A pH meter is used to measure the pH of the sample on an aliquot 2 hours of sampling. Before each reading, the probe is thoroughly rinsed with de-ionized water. The pH is read to one-tenth of a pH unit.

8.9 A YSI Model 33 S-C-T with a YSI 3300 Conductivity/Temperature Probe is used for conductivity measurement on an aliquot within 2 hours of sampling. The meter is zeroed and "red-line" adjusted before any measurements are made. The conductivity is then read to three significant figures and the temperature is then read to three significant figures and the temperature of the sample at the time of conductivity measurement is also recorded.

8.10 Sample integrity sheets and chain-of-custody sheets shall be filled out in duplicate using carbon paper. The copy shall be included with the samples sent to the laboratory. The originals shall be delivered to the task leader.

8.11 The samples shall be packed in an ice cooler (at $4^{o}C$) if necessary, the sampler will be freighted to the analytical laboratory, and a sample shipping and receiving record form shall be filled out in duplicate with a copy accompanying the samples to the laboratory.

8.12 The beakers and other laboratory instruments shall be kept clean at all times by rinsing with distilled water before and after use.

8.0 PROCEDURE

8.1 The determination of the permeability properties of soils shall be thorough and accurate and carried out in accordance with the standard procedures outlined below.

8.2 The permeability characteristics of soil shall be determined by the procedures outlined in the ASTM reference "Suggested Method of Tests for Permeability of Undisturbed Soil or Rock Specimens". ASTM STP 479.

TITLE	EFFECTIVE DATE	REV. LEVEL
TP-1.4-2 TECHNICAL PROCEDURE FOR DETERMINATION OF IN-PLACE DENSITY OF SOILS		
PREPARED BY Douglas J. Howell Feb 11 1985 · APPROVED [signature] 2-11-85 · APPROVED [signature] Feb 11/85		1
CONTROLLED DOCUMENT		

Revision Level	Page No.	Section No.	Revision Made TP-1.4-2
1	Page 1	Entire	Reference to Work Instructions has been changed to Technical Procedure.

1.0 PURPOSE

This Technical Procedure is to be used to establish uniform and consistent procedures for the determination of in-place density of soils.

2.0 APPLICABILITY

This Technical Procedure is applicable to all persons or parties engaged in determining the in-place density of soils for foundation investigations.

3.0 DEFINITIONS

In-place Density. The weight per unit volume of soil as it exists in situ.

4.0 REFERENCES

4.1 ASTM Standards, 1980. Standard Test Method for Density of Soil in Place by the Sand-Cone Method, D 1556-64, American Society for Testing and Materials, Philadelphia, PA.

4.2 ASTM Standards, 1980. Standard Test Method for Density of Soil in Place by the Rubber-Balloon Method, D 2167-66, American Society for Testing and Materials, Philadelphia, PA.

5.0 DISCUSSION

None.

6.0 RESPONSIBILITY

6.1 Each Individual, as designated by the Project Manager, shall be responsible for completing the in-place density of soils test as described in this technical procedure.

6.2 The Field Manager, as designated by the Project Manager, shall be responsible for making observations to determine the effective and correct implementation of the in-place density tests.

7.0 EQUIPMENT AND MATERIALS

7.1 The apparatus required for the determination of in-place density using the sand cone method is described in Section 2 of ASTM Method D 1556-64.

7.2 The apparatus required for the determination of in-place density using the rubber balloon method is described in Section 2 of ASTM Method D 2167-66.

8.0 PROCEDURE

8.1 The Field Manager shall determine which test is the most applicable to the materials and conditions encountered at the test site.

8.2 The individual performing the test shall follow the procedures outlined in ASTM D 1556-64 if the chosen method for determining the in-place density is the sand-cone method.

8.3 The individual performing the test shall follow the procedures outlined in ASTM D 2167-66 if the chosen method for determining the in-place density is the rubber balloon method.

8.4 Stratigraphic changes observed while performing the in-place density testing shall be noted on the worksheet. It is intended that testing be performed in homogenous materials.

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TITLE	EFFECTIVE DATE	REV. LEVEL
TP-2.2-3 TECHNICAL PROCEDURE FOR DETECTING THE PRESENCE OF VOLATILE ORGANICS IN WATER SAMPKES		
PREPARED BY 4/9/84 Douglas J. Mod APPROVED 4-9-85 APPROVED 4/26/85		
CONTROLLED DOCUMENT		

Revision Level	Page No.	Section No.	Revision Made
0	None	None	New Procedure

1.0 PURPOSE

This Technical Procedure is to be used to detect the presence of volatile organics in water samples. The detection of volatile constituents in the Water sample is used to screen which samples are sent to a laboratory for quantitative analysis.

2.0 APPLICABILITY

This Technical Procedure is applicable to all persons determining the presence of volatile organics within water samples. This Procedure is qualitative and cannot be considered quantitative.

3.0 DEFINITIONS

3.1 Septum-type cap. An air-tight teflon-lined cap with the ability to puncture and withdraw a sample.

3.2 Headspace. The atmosphere contained within an air-tight jar.

4.0 REFERENCE

U.S. EPA. 1980 (Revised 1982). Test Methods for Evaluating Solid Waste. Office of Solid Waste, SW-846, Washington, D.C.

5.0 DISCUSSION

None

6.0 RESPONSIBILITY

All individuals engaged in the collection of waters and field testing of volatile organic constituents are responsible for compliance with this Procedure.

7.0 EQUIPMENT OR MATERIALS

7.1 Portable gas chromatograph (GC)
7.2 GC calibration equipment
7.3 Glass jars with air-tight caps
7.4 Glass vial (40 ml) with air-tight, teflon-lined septum-type caps
7.5 Field log book
7.6 Sample labels

7.7 Sample integrity forms

7.8 Chain-of-custody forms and seals

8.0 PROCEDURE

8.1 Water samples, that are obtained according to TP-1.2-14 "Technical Procedure for Collection of Groundwater Quality Samples" will be field tested for headspace gases. Two portions of the extracted sample will be immediately taken and placed in separate air tight glass jars. One 250 to 500 ml jar (1/2 full of sample) will be fitted with an air-tight cap. The other vial (40 ml with an air-tight, septum-type cap) will be filled with the sample (no air bubble present) and stored for laboratory analysis, if warranted.

8.2 The 250 to 500 ml glass jar container and contents with the air-tight cap will be agitated . It is optional to warm the sample in a bath of hot water to approximately 90°C.

8.3 A sample of the headspace gas is withdrawn through the portable gas chromatography (GC) that has been properly calibrated.

8.4 The relative response to the target parameters are recorded and used to evaluate which samples (in the 40 ml vial) are to be sent to the laboratory for quantitative analysis. This field analysis is not for quantifying the volatile organic content, but for identifying the presence of target volatile constituents.

8.5 Samples to be sent to the laboratory are then labeled, stored in the dark at 4°C, logged and documented with a sample integrity data form and a chain-of-custody form.

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TITLE TP-2.2-1 TECHNICAL PROCEDURE FOR DETECTING THE PRESENCE OF VOLATILE ORGANICS IN SOIL SAMPLES	EFFECTIVE DATE	REV. LEVEL
PREPARED BY Douglas J. Morell Feb 11, 1985 APPROVED 2.11.85 APPROVED Feb 11/85		∅
CONTROLLED DOCUMENT		

1.0 PURPOSE

This Technical Procedure is to be used to detect the presence of volatile organics in soil samples. The detection of volatile constituents in the soil sample is used to screen which samples are sent to a laboratory /a quantitative analysis.

2.0 APPLICABILITY

This Technical Procedure is applicable to all persons determining the presence of volatile organics within soil samples. This Procedure is qualitative and cannot be·considered quantitative.

3.0 DEFINITIONS

3.1 Septum-type cap. An air tight teflon lined cap with the ability to puncture and withdraw an air sample.

3.2 Headspace. The atmosphere contained within an air-tight jar.

4.0 REFERENCE

4.1 U.S. EPA. 1980 (Revised 1982). Test Methods for Evaluating Solid Waste. Office of Solid Waste, SW-846, Washington, D.C.

4.2 Golder Associates Technical Procedure TP-1.2-5, Technical Procedure for Drilling and Sampling of Soils

5.0 DISCUSSION

None

6.0 RESPONSIBILITY

All individuals engaged in the collection of soils and field testing of volatile organic constituents are responsible for compliance with this Procedure.

7.0 EQUIPMENT OR MATERIALS

7.1 Portable gas chromatography (GC)

7.2 GC calibration equipment

7.3 Glass jars with air-tight, teflon-lined caps

7.4 Glass jars with air-tight, teflon-lined septum-type caps

7.5 Field log book

7.6 Sample labels

7.7 Sample integrity forms

7.8 Chain-of-custody forms and seals

8.0 PROCEDURE

8.1 Soil samples that are obtained either by split-tube or drive-tube techniques (see Technical Procedure TP-1.2-5) will be field tested for headspace gases. Two portions of the extracted sample will be immediately taken and placed in separate air tight glass jars. One jar (1/2 full of sample) will be fitted with a septum-type cap. The other jar will be filled with the sample and stored for laboratory analysis, if warranted.

8.2 The glass container and contents with the septum-type cap will be warmed in a bath of hot water to approximately 90°C.

8.3 A sample of the headspace gas is withdrawn through the portable gas chromatography (GC) that has been properly calibrated.

8.4 The relative response to the target parameters are recorded and used to evaluate which samples are to be sent to the laboratory for quantitative analysis. This field analysis is not for quantifying the volatile organic content, but for identifying the presence of target volatile constituents.

8.5 Samples to be sent to the laboratory are then labeled, stored in the dark at 4°C, logged and documented with a sample integrity data form and a chain-of-custody form.

Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

TITLE TP-1.4-11 TECHNICAL PROCEDURE FOR SINGLE BOREHOLE DRAWDOWN AND RECOVERY PUMP TEST	EFFECTIVE DATE	REV. LEVEL
PREPARED BY Douglas J. Morell Feb. 11, 1985 APPROVED [signature] 2-11-85 APPROVED [signature] Feb 11/85		Φ
CONTROLLED DOCUMENT		

Revision Level	Page No.	Section No.	Revision Made
0	None	None	New Procedure

1.0 PURPOSE

This Technical Procedure is to be used to establish a uniform procedure for executing a single borehole pump test.

2.0 APPLICABILITY

This Technical Procedure is applicable to all persons or parties involved with single borehole pump testing.

3.0 DEFINITIONS

3.1 Single Borehole Pump Test: A controlled field experiment conducted in a single borehole to determine the hydraulic properties of water-bearing rocks. The test is performed by measuring water level drawdown in a pumping well as a function of time.

3.2 Flow Meter: A device that measures the cumulative volume of discharged water (Flow Volume Meter) or the volume of water discharged per unit time (Flow Rate Meter). The particular device selected depends on site conditions and the magnitude of the discharge rate.

3.3 Measuring Point: A permanent zero-depth datum to which water level measurements are referenced. The borehole collar is commonly utilized as a measuring point.

3.4 Drawdown: Change in water level from static conditions.

4.0 REFERENCES

Cooley, R.L., et al, 1972. Hydrologic Engineering Methods for Water Resources Development, Vol. 10-Principles of Ground-Water Hydrology, Section 7.04, U.S. Army Corp of Engineers (HEC-IHD-1000).

5.0 DISCUSSION

The results of single borehole tests can be significantly affected by borehole skin and wellbore storage. Calculated hydraulic parameters are generally considered order of magnitude estimates.

6.0 RESPONSIBILITY

6.1 Each Field Engineer performing a single borehole pump test shall be responsible for proceeding with testing in compliance with this work instruction.

6.2 Task Leader shall be responsible for:

- o Direct supervision of personnel performing the test.
- o Assurance that equipment and materials are available to permit accomplishment of the task.
- o Determining pumping rate, time intervals between readings and duration of the test.

7.0 EQUIPMENT AND MATERIALS

7.1 Data sheets for pump test-field record (Exhibits A and B)

7.2 Flow meter

7.3 Electric water level sounder and extra batteries

7.4 Watch

7.5 Clip Board

7.6 Field notebook

7.7 Folding Rule or spring-wound tape

8.0 PROCEDURES

8.1 Record data at top of Single Borehole Pump Test Field Record data sheets (Exhibits A and B).

8.2 Install pump, flow meter, and discharge line on well.

8.3 Monitor water level in well for a specified period of time to determine static water level. Refer to Golder Associates' Quality Assurance TP-1.4-6 for instructions on measurements of water levels. Measurements shall be taken as depth below a specified permanent measuring point.

8.4 Predetermine pumping rate and duration.

8.5 Predetermine time for initial readings.

8.6 Begin pumping at predetermined rate and commence taking and recording measurements of depth to water at reasonable time intervals. Measurements shall be taken using the same measuring point as in 8.3.

8.7 During pumping, flow meter readings are recorded at reasonable time intervals.

8.8 Discontinue pumping at a specified time.

8.9 Continue to take water level measurements after pumping for a specified period of time.

8.10 Obtain copies of barametric records for the test period from the nearest weather station.

EXHIBIT A

SINGLE BOREHOLE PUMP TEST FIELD RECORD

WATER LEVEL MEASUREMENTS

Borehole No.______________________________ Sheet______ of ______

Ground Surface Elevation (MSL) ____________________________________

Depth of Screened Interval (Below ground surface)__________________________

Measuring Point Description____

Measuring Point Elevation (MSL) ____

Static Depth of Water (Below measuring point)______________________________

Pumping Started Time: ____________ Date: __________

Pumping Ended Time: ____________ Date: __________

Date	Time	Time Since Beginning of Pumping	Time Since End of Pumping	Depth to Water	Drawdown	Water Level Elevation	Remarks

Project No.: ________________ Technician: ______________________

EXHIBIT B

SINGLE BOREHOLE PUMP TEST FIELD RECORD

FLOW METER MEASUREMENTS

Borehole No.______________________________ Sheet______ of _______

Ground Surface Elevation (MSL) ____________________________________

Depth of Screened Interval (Below ground surface)___________________________

Flow Meter Type: ______ Flow Rate Meter

______ Flow Volume Meter/Initial Reading _____________

Pumping Started Time: _____________ Date: __________

Pumping Ended Time: _____________ Date: __________

Date	Time	Time Since Beginning of Pumping	Flow Rate Meter Reading	FLow Volume Meter Reading	Remarks

Project No.: __________________ Technician: ________________________

Golder Associates
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TITLE TP-2.2-2 TECHNICAL PROCEDURE FOR CONDUCTING NATURAL GAMMA, NEUTRON AND GAMMA-GAMMA BOREHOLE GEOPHYSICAL SURVEYS	EFFECTIVE DATE	REV. LEVEL
PREPARED BY Douglas J Morell Feb 11, 1985 / APPROVED [signature] 2.11-85 / APPROVED [signature] Feb 11/85		ϕ
CONTROLLED DOCUMENT		

Revision Level	Page No.	Section No.	Revision Made
0	None	None	New Procedure

1.0 PURPOSE

A geophysical borehole logging survey will be performed with two objectives in mind: 1) to define the lithology, depths, and thicknesses of the subsurface strata; and, 2) to estimate the porosity of the water bearing strata; and 3) to locate the existence of perched saturated zones.

2.0 APPLICABILITY

This Technical Procedure is applicable to all persons having access to radioactive borehole probes and are licensed to operate them.

3.0 DEFINITIONS

3.1 Natural Gamma Survey. A geophysical survey recording natural gamma emissions.

3.2 Neutron Survey. A geophysical survey where neutrons are counted and recorded after excitation with neutrons from a source.

3.3 Gamma-Gamma Survey. A geophysical survey where gamma emissions are recorded after excitation by a gamma source.

4.0 REFERENCES

Telford, W.M., Geldart, L.P., Sheriff, R.E. and Keys, D.A., 1976, Applied Geophysicals. Press Syndicate of the University of Cambridge, New York, NY. 860 pages.

5.0 DISCUSSION

None.

6.0 RESPONSIBILITY

All individuals engaged in conducting geophysical borehole logs with natural gamma, neutron and gamma-gamma probes are responsible for compliance with this procedure.

7.0 EQUIPMENT AND MATERIALS

7.1 Natural gamma probe

7.2 Neutron probe

7.3 Gamma-gamma probe

7.4 Calibrated cable odometer and reel for lowering the probes

7.5 Strip chart recorder for recording signals from the probes

8.0 PROCEDURES

8.1 A suite of geophysical borehole logs will be acquired in 11 existing wells: 7 private wells and 4 monitoring wells. All of the wells are cased, some with steel and some with plastic casing. All the holes are within 1/4 mile of each other and no access problems are anticipated. The average depth of the wells is 225 feet with the smallest well diameter 2 inches or greater.

8.2 Three sets of logs will be acquired during the course of the survey: natural gamma, neutron, and gamma-gamma (density).

8.3 The natural gamma probe can be used in cased wells for analysis of lithology. Natural gamma ray emissions are detected with a scintillation counter. This probe is valuable for identifying aquitards such as clay and shales in cased holes.

8.4 The neutron probe can also be used in a cased, water-filled hole, and is used to confirm lithology as well as aid in porosity evaluation. An AmBe241 (Americum-Beryllium) source is used to thermalize neutrons. A thermal neutron detector, filled with helum 3, is used to count the neutrons that are thermalized. When the hydrogen index is high, more neutrons are thermalized near the source, and fewer neutrons reach the detector. This detector is insensitive to gamma radiation.

8.5 The gamma-gamma (density) probe may also be used in water-filled holes and is best suited for estimating formation porosity, lithology, and fluid content. A Ce137 (Cesium) source is used to generate gamma rays, the reflections of which are recorded on a scintillation counter. In uncased holes, a caliper is used to provide compensation for variations in borehole diameter, but this will not be possible in the cased holes that will be available for this survey. Lacking this compensation capability, a non-compensated bulk density log will be generated at the time of the survey. The Cesium source is mounted so as to direct gamma rays into the formation. As the gamma rays collide with electrons, some are absorbed and some are scattered. The reflected (diffused) gamma rays are continuously counted by the scintillation counter. The logarithm of the counting rate varies inversely with the density of the formation. The porosity log can either be generated in the field using a pre-selected formation density or in the laboratory using formation specific grain densities. A laboratory porosity log will be generated for this survey.

8.6 The actual field logging procedure is relatively straightforward. An instrumentation van is backed-up to the borehole, the probes are calibrated, and the probes are then lowered into the borehole at a uniform rate. Probe elevation is determined from a factory calibrated wire odometer which is part of the probe raising and lowering electronics. The resulting signals from the probes are displayed real-time in the field onto a strip-chart recorder. The signals are also digitally recorded for laboratory generated porosity logs.

8.7 The field work for the geophysical borehole logging survey utilizes radioactive and natural sources, the emissions of which are detected, with electronic devices that produce electrical signals that are then recorded on magnetic media and displayed on hard copy strip-chart recorders. The principal Quality Assurance concerns are the locations of the source (depth) in the borehole and the accuracy of the electronic recording/display system.

8.8 The location of the probes in the borehole is observed visually and recorded electronically from the readout of an electric trip odometer. The odometer is calibrated periodically (approximately every six months) by Geo-Log, the equipment suppliers, using a borehole of known characteristics and depth.

8.9 Each individual probe used for this suite of geophysical borehole logs is calibrated using test blocks of known density following standard API gamma ray, neutron, and density calibration procedures.

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TITLE	EFFECTIVE DATE	REV. LEVEL
TP-3.1-5 TECHNICAL PROCEDURE FOR THE LABORATORY CLASSIFICATION AND DESCRIPTION OF SOILS		
PREPARED BY Douglas J. Morell Feb 11, 1985 APPROVED L. Ashley 2-11-85 APPROVED R. Burgess Feb 11/85		2
CONTROLLED DOCUMENT		

Revision Level	Page No.	Section No.	Revision Made TP-3.1-5
2	Entire procedure		Reference to Work Instruction was changed to Technical Procedure.

1.0 PURPOSE

This technical procedure describes a method for classifying soils for engineering purposes based on laboratory detremination of particle-size characteristics, liquid limit, and plasticity index. It shall be used to provide a precise classification of all representative foundation materials.

2.0 APPLICABILITY

This technical procedure is applicable to all persons or parties engaged in the Laboratory Classification of Soils.

3.0 DEFINITIONS

3.1 Classification. The consistent and accurate description of soils according to standard procedures which enable the engineering properties of the soils to be characterized.

3.2 Particle Size Analysis. The quantitative determination of the distribution of particle sizes in soils. The process of separating a soil aggregate into fractions is achieved by sieving coarse material (particle size larger than 75 um) and sedimenting fine material (particle size smaller than 75 um).

3.3 Liquid Limit. The water content of a soil, expressed as a percentage of the weight of the oven-dried soil at the boundary between the liquid and plastic states.

3.4 Plastic Limit. The water content of a soil, expressed as a percentage of the weight of the oven-dried soil at the boundary between the plastic and semi-solid states.

3.5 Plasticity Index. The numerical difference between the liquid limit and the plastic limit, indicating the range of water contents over which the soil possesses plastic properties.

4.0 REFERENCES

4.1 ASTM Standards, 1980. Classification of Soils for Engineering Purposes, D 2487-69, American Society for Testing and Materials, Philadelphia, PA.

4.2 ASTM Standards, 1980. Dry Prearation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants, D421-58, American Society for Testing and Materials, Philadelphia, PA.

4.3 ASTM Standards, 1980. Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants, D2217-66, American Society for Testing and Materials, Philadelphia, PA.

4.4 ASTM Standards, 1980. Standard Test Method for Liquid Limit of Soils, D423-66, American Society for Testing and Materials, Philadelphia, PA.

4.5 ASTM Standards, 1980. Standard Test method for Plastic Limit and Plasticity Index of Soils, D424-59, American Society for Testing and Materials, Philadelphia, PA.

4.6 ASTM Standards, 1980. Standard Method for Particle Size Analysis of Soils, D422-63, American Society for Testing and Materials, Philadelphia, PA.

4.7 ASTM Standards, 1980. Standard Recommended Practice for Description of Soils, D2488-69, American Society for Testing and Materials, Philadelphia, PA.

4.8 ASTM Standards, 1980. Standard Test Method for Amount of Material in Soils Finer than the No. 200 (75-mm) Level, D1140-54, American Society for Testing and Materials, Philadelphia, PA.

5.0 DISCUSSION

None.

6.0 RESPONSIBILITY

6.1 The Laboratory Technician, as designated by the Project Manager, shall be responsible for the laboratory classification of soils as described in this procedure.

6.2 The Field Manager, as designated by the Project Manager, shall be responsible for making observations to determine effective and correct implementation of the laboratory classification of soils.

7.0 EQUIPMENT OF MATERIALS

7.1 Balance sensitive to 0.1g

7.2 Balance sensitive to 0.01g

7.3 Riffle sampler or sample splitter for quartering samples

7.4 Thermostatically controlled drying oven

7.5 Sieves - A series of sieves conforming to the requirements of ASTM Specification E11. A full set of sieves includes the following:

Sieve Size	Sieve Size
3 in.	No. 10
2 in.	No. 20
1-1/2 in.	No. 40
1 in.	No. 60
3/4 in.	No. 140
3/8 in.	No. 200
No. 4	

7.6 Liquid limit device

7.7 Grooving tool

7.8 Mortar and rubber-covered pestle

7.9 Evaporating dishes

7.10 Spatulas

7.11 Sample containers which prevent moisture loss

7.12 Ground glass rolling plate.

8.0 PROCEDURE

8.1 Laboratory classification of soils shall be thorough and accurate and carried out in accordance with the standard procedures outlined below.

8.2 Test samples shall be obtained from the field sample using the procedure outlined in Section 4 ASTM Method D 2487.

8.3 The test sample shall be classified as coarse-grained or fine-grained in accordance with Section 5 of ASTM Method D 2487. The procedure for determining the percentage of the test sample finer than the No. 200 sieve is described in ASTM Method D 1140.

8.4 If the soil is classified as coarse-grained, detailed classification shall be carried out as described in Section 6 of ASTM Method D 2487. Sample for particle size analysis, liquid limit, and plasticity index shall be selected in accordance with ASTM Method D 421 or Method D 2217. The cumulative particle size distribution of the fractions coarser than the No. 200 sieve shall be determined in accordance with ASTM Method D 422. If more than 12 percent of the test sample passes the No. 200 sieve, the liquid limit and placticity index of the soil shall be determined in accordance with ASTM Methods D 423 and D 424 respectively.

8.5 Each sample shall be described according to the procedures outlined in ASTM Method D 2488.

8.6 A minimum of 3 grain size analyses shall be conducted for each major sand and gravel lithology. A minimum of 3 atterburg limits and hydrometer tests shall be conducted for each major salt/clay lithology.

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TITLE	EFFECTIVE DATE	REV. LEVEL
TP-3.1-1 TECHNICAL PROCEDURE FOR THE DETERMINATION OF THE MOISTURE CONTENT OF SOILS		
PREPARED BY Douglas J. Morell Feb 11, 1985 — APPROVED [illegible] 2.11.85 — APPROVED [illegible] Feb 11/85		1
CONTROLLED DOCUMENT		

Revision Level	Page No.	Section No.	Revision Made TP-3.1-1
1	Page 1	Sect. 2.0	Changed "foundation" to "geotechnical".
	Entire		Changed work instructions reference to Technical Procedure.

1.0 PURPOSE

This Technical Procedure describes a method for determining the moisture content of soils. The moisture content of cohesive saturated soils provides an index of the engineering properties of these soils. Moisture contents of all in situ density tests and compaction tests are also required to enable definition of the dry densities of the soils.

2.0 APPLICABILITY

This Technical Procedure is applicable to all persons or parties engaged in the determining of moisture content of soils for geotechnical investigations.

3.0 DEFINITIONS

Moisture or Water Content. The ratio, expressed as a percentage, of the weight of water in a given mass of soil to the weight of the solid particles.

4.0 REFERENCES

ASTM Standards, 1980. Standard Test Method of Laboratory Determination of Moisture Content of Soil, D 2216-71, American Society for Testing and Materials, Philadelphia, PA.

5.0 DISCUSSION

None.

6.0 RESPONSIBILITY

6.1 The Laboratory Technician, as designated by the Project Manager, shall be responsible for completing the laboratory determination fo the moisture content of soil as described in Section 8.0 of this procedure.

6.2 The Field Manager, as designated by the Project Manager, shall be responsible for making observations to determine the effective and correct implementation of the moisture content test.

7.0 EQUIPMENT AND MATERIALS

The apparatus required for the determination of the moisture content of soils is described in Section 3 of ASTM Method D 2216.

8.0 PROCEDURE

8.1 The determination of the moisture content of soils shall be thorough and accurate, and carried out in accordance with the standard procedures outlined below.

8.2 A representative quantity of moist soil shall be selected as described in Section 4 of ASTM Method D 2216.

8.3 The moisture content shall be determined as described in Sections 5 and 6 of ASTM Method D 2216.

Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

TITLE	EFFECTIVE DATE	REV. LEVEL
TP-3.1-12 TECHNICAL PROCEDURE FOR DETERMINATION OF PERMEABILITY OF SOIL SAMPLES		
PREPARED BY Douglas J. Morell Feb 11, 1985 — APPROVED [signature] 2-11-85 — APPROVED [signature] Feb 11/85		1
CONTROLLED DOCUMENT		

1.0 PURPOSE

This Technical Procedure describes a method for determining the permeability of either undisturbed or recompacted soil samples.

2.0 APPLICABILITY

This Technical Procedure is applicable to all persons or parties engaged in the determination of the permeability of soil samples.

3.0 DEFINITIONS

Permeability. The permeability is the velocity with which water under a gradient of unity passes through soil materials.

4.0 REFERENCE

American Society for Testing and Materials STP 479, Special Procedures for Testing Soil and Rock for Engineering Purposes, June 1970, Suggested Method of Test for Permeability of Undisturbed Soil or Rock Specimens, pp. 150-156.

5.0 DISCUSSION

None.

6.0 RESPONSIBILITY

6.1 The Laboratory Technician as designated by the Project Manager shall be responsible for determining the permeability characteristics of soil samples.

6.2 The Task Leader as designated by the Project Manager shall be responsible for making observations to determine the effective and correct implementation of the determination of the permeability properties of soil samples.

7.0 EQUIPMENT AND MATERIALS

The apparatus required for determining the permeability properties of soil is as described in the chapter referenced above in the ASTM publication.

Revision Level	Page No.	Section No.	Revision Made TP-3.1-12
1	Entire Procedure		Reference to Work Instruction was changed to Technical Procedure.

APPENDIX A
GLOSSARY OF TERMS

Audit

A systematic check to determine the quality of operation of some function or activity. Audits may be of two basic types: 1) performance audits in which quantitative data are independently obtained for comparison with routinely obtained data in a measurement system, or 2) system audits of a qualitative nature that consist of an on-site review of a laboratory's quality assurance system and physical facilities for sampling, calibrations, and measurement.

Data Quality

The quality of data bears on its ability to satisfy a given purpose. The characteristics of major importance are accuracy, precision, completeness, representativeness, and comparability. These characteristics are defined as follows:

Accuracy - the degree of agreement of a measurement (or an average of measurements of the same thing), X, with accepted reference or true value, T, usually expressed as the difference between the two values, X-T, or the difference as a percentage of the reference or true value, 100 (X-T)/T, and sometimes expressed as a ratio, X/T. Accuracy is a measure of the bias in a system.

Precision - a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision is best expressed in terms of the standard deviation. Various measures of precision exist depending upon the "prescribed similar conditions."

Completeness - a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct normal conditions.

Representativeness - expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

Comparability - expresses the confidence with which one data set can be compared to another.

Data Validation

A systematic process for reviewing a body of data against a set of criteria to provide assurance that the data are adequate for their intended use. Data validation consists of data editing, screening, checking, auditing, verification, certification, and review.

Environmentally Related Measurements

A term used to describe essentially all field and laboratory investigations that generate data involving 1) the measurement of chemical, physical, or biological parameters in the environment, 2) the determination of the presence or absence of criteria or priority pollutants in waste streams, 3) assessment of health and ecological effect studies, 4) conduct of clinical and epidemiological investigations, 5) performance of engineering and process evaluations, 6) study of laboratory simulation of environmental events, and 7) study or measurement on pollutant transport and fate, including diffusion models.

Performance Audits

Procedures used to determine quantitatively the accuracy of the total measurement system or component parts thereof.

Quality Assurance

The total integrated program for assuring the reliability of monitoring and measurement data. A system for integrating the quality planning, quality assessment, and quality improvement efforts to meet user requirements.

Quality Assurance Program Plan

An orderly assembly of detailed and specific procedures which delineates how data of known and accepted quality data is produced for a specific project. (A given agency or laboratory would have only one quality assurance plan, but would have quality assurance project plan for each of its projects.)

Quality Control

The routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process.

Technical Procedure (TP)

A written document which details an operation, analysis or action whose mechanisms are thoroughly prescribed and which is commonly accepted as the method of performing certain routine or repetitive tasks.